DOCUMENT RESUME

ED 320 773 SE 051 514

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TITLE Cooperative Learning in a College Science Course for Preservice Elementary Teachers.
PUB DATE 90
NOTE 19p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Attitude Measures; *College Science; *Cooperative Learning; Elementary School Teachers; Higher Education; *Laboratory Experiments; Methods Courses; *Preservice Teacher Education; Science Instruction; *Science Teachers; Teaching Methods; *Teaching Skills

ABSTRACT

This study explored the impact of cooperative learning in a college level laboratory science course by comparing classes taught by a conventional lab-lecture technique. Students in a basic science skills course for preservice elementary teachers participated over a 14-week period. Instruments used were the Science Attitude Survey, Test of Logical Thinking, Learning Preference Scale, an observational instrument, and a student perception of treatment instrument. In addition, a comprehnsive examination and two lab practicals measuring the development of lab skills were used. No significant main effects of treatment or interactions between treatment and reasoning ability, learning preference, or science comfort level were found. The subtlety of differences in treatment could account for the failure to find significant differences. Some explanations on the results and implications for teaching were discussed. (YP)

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# Cooperative Learning in a College Science Course for Preservice Elementary Teachers

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## Introduction

Results of recent studies indicate that students in the United States are lagging behind students in most other major industrialized nations in science and mathematics achievement (Linn, 1987). Further, there is evidence that student interest in science and science-related careers rapidly declines from age nine to around age nineteen (Johnson & Johnson, 1982).

In attempting to solve these problems, a significant amount of attention has been given to the examination of the experiences of elementary students in science classes which has been described as "at best limited" (Pratt, 1981). Part of this effort has focused specifically upon the problem of elementary teachers' negative attitudes toward science and science teaching (Gabel & Rubba, 1979; Sherwood & Gabel, 1980; Shrigley, 1974a; Shrigley, 1974b; Shrigley & Johnson, 1974 for example).

The perceived problem in science and mathematics education has also sparked renewed interest in the development, evaluation, and implementation of new methods of instruction which might facilitate improvement in achievement and interest in these disciplines. One such alternative which has gained considerable prominence in recent years is cooperative learning (Stallings & Stipek, 1986).

As defined by Deutsch (1949), a cooperative goal structure is one in which the goal of an individual is positively correlated with the goal of the group. This

concept has provided the basis for the development of a variety of cooperative techniques which have been applied in educational settings. In general, cooperative learning has been shown to have positive effects over a wide range of content areas upon achievement, as well as upon a variety of affective variables, though the superior effects are not without contradiction (see Johnson, Johnson & Maruyama, 1983; Johnson, Maruyama, Johnson, Nelson & Skon, 1981; Sharan, 1980; Slavin, 1980; Slavin, 1983; Slavin, 1988 for reviews).

It is interesting that, of the hundreds of studies examining some facet of cooperative learning, relatively few have involved the science content area. Those studies which have examined the effects of cooperative learning in the science classroom have, almost without exception, involved students in grades one through twelve (Humphreys, Johnson, & Johnson, 1982; Tjosvold, Marino, & Johnson, 1977; Okebukola, 1986; for example). Very few studies designed to investigate the effects of cooperative learning have dealt with students at the college level (Haines & McKeachie, 1967; Julian & Perry, 1967; Knoblauch, 1978; McClintock & Sonquist, 1976, for example). Of those studies related to examination of cooperative learning in college courses, even fewer involve preservice teachers (Baird & Koballa, 1986; Hwong, 1986; Sherman, 1986, for example).

## Statement of the Problem

The purpose of this study was to explore the impact of cooperative learning in a college level laboratory science

course by comparing classes taught by a more conventional, lab-lecture technique with classes taught utilizing structured cooperative learning techniques. Because of the previously mentioned impact of elementary teachers upon science instruction, subjects selected for the study were preservice elementary teachers. Of particular interest were possible differential effects upon achievement, development of laboratory skills, development of specific science concepts, and attitude toward science and science teaching for students of high and low reasoning ability; students exhibiting different learning preferences; and students demonstrating varying levels of comfort relative to science.

## Methodology

### Design and Subjects

The design of the study, which extended over the period of fourteen weeks, was a non-equivalent comparison group design (Campbell & Stanley, 1963). Students in four sections of a three-hour basic science skills course for preservice elementary students were participants. Initial enrollment in the four classes at a major midwestern university was 95; however, due to mortality unrelated to the study, data from 89 subjects were analyzed. The large majority of the students were white and female.

### Instruments

Several instruments were administered in the definition of independent variables and the assessment of dependent

variables. A 50-item multiple choice comprehensive exam served as both a pre-test (KR-20, 0.77) as well as part of the final exam (KR-20, 0.87). Other course exams included the first test, (Spearman-Brown, 0.75), the second test (Spearman-Brown, 0.74) and a second part of the final exam (Spearman-Brown, 0.84). Academic achievement was measured by the mean score of the two tests and the two parts of the final exam.

The development of laboratory skills was measured by the weighted mean of the two laboratory practicals. As a result of the cumulative nature and greater complexity of the second laboratory practical, scores on this instrument were weighted three times the scores on the first practical. Blind grading procedures were used in grading these open-ended, hands-on laboratory tests.

Three concept areas heavily emphasized in the course were evaluated using a separate surface area/volume-states of matter concept test developed in a prior study (Brown, Gabel, Shepard & Rice, 1987). The test consisted of eleven basic items each followed by between nine and fifteen explanations for the answer to the basic item (Cronbach's alpha, 0.94).

Total score and scores on subscales of the Science Attitude Survey (Cooney & Yeany, 1987) were used to assess attitude toward science, attitude toward science teaching, and comfort level relative to science. The latter variable was assessed using a subscale of the Science Attitude Survey defined by the researcher. Slightly modified from the

original format for ease in scoring, the survey was given as a pre-test (Cronbach's alpha, 0.84) and a post-test (Cronbach's alpha, 0.82). Reliabilities of the subscales ranged from 0.35 to 0.80 (pre-test) and from 0.32 to 0.83 (post-test).

Two instruments were administered for characterization of students relative to learning style preference and formal reasoning ability. Scores on the Test of Logical Thinking (TOLT) (Tobin & Capie, 1981) was used to divide the students into two groups, formal and non-formal thinkers. Reliability of this instrument for students in this study was 0.74 (KR-20). The Learning Preference Scale Students, American Revision (Barnes, Owens & Straton, 1980) is composed of three subscales for identification of students' preferred learning styles: cooperative (Cronbach's alpha, 0.78), competitive (Cronbach's alpha, 0.67), or individualistic (Cronbach's alpha, 0.76).

Two instruments were developed by the researcher to aid in the validation of possible treatment differences. The Observational Instrument (Cronbach's alpha, 0.96) was developed for use by independent observers who made classroom visits. The Student Perception of Treatment instrument (Cronbach's alpha, 0.90) was administered to students near the end of the semester. Both of these instruments focused upon behaviors previously identified by researchers (Johnson & Johnson, 1975) as indicative of cooperative involvement.

## Variables

Based upon the purposes of the study, the following independent variables were defined: treatment, cooperative or comparison; reasoning ability, formal or non-formal; comfort level relevant to science, high or low; and learning style preference: cooperative, competitive, or individualistic. Dependent variables of interest included performance variables and attitude variables. Three types of performance were assessed: achievement, development of laboratory skills, and understanding of three concept areas. Total score and scores on two subscales of the Science Attitude Survey (Cooney & Yeany, 1987) were used respectively as measures of three dependent affective variables: attitude toward science, attitude toward science teaching, and comfort level relevant to science.

## Treatments

Two instructors each taught two of the four classes involved in the study. One of each instructor's classes served as part of the comparison group and the other as part of the experimental or cooperative group. Thus, both the comparison and the experimental groups consisted of two classes.

Several procedures were used in defining the cooperative treatment. First, students were placed in heterogeneous groups based upon GPA. These cooperative teams were

encouraged to work as a group in carrying out labs, discussing results and answers to questions, and completing lab reports.

Several procedures designed to facilitate the development of cooperative group processes were utilized in the cooperative classes. These included a training exercise, "Broken Circles," (Nancy and Ted Graves in Cohen, 1986); the use of cooperative team checklists (Nelson, 1988); and the assignment of roles to each of the four cooperative team members (Johnson & Johnson, 1975).

Two major components of the cooperative treatment were the completion of the team lab report and the implementation of a bonus point system based on team performance. In completing the team lab report, all four team members, carrying out their roles, worked together in carrying out the lab activity and in writing the group lab report. These reports were completed in class. All team members received the grade on the team lab report.

The bonus point system (Slavin, 1988) was based upon performance on six short quizzes given periodically during the semester. Bonus points awarded individual members of the cooperative were based upon the scores of all of the team members.

Both classes in the comparison group received instruction fairly typical of traditional college laboratory science courses. While four students sat at each lab table, students worked in pairs of their own choosing to facilitate efficient

use of equipment and materials. All laboratory reports were completed individually.

Individual grades were assigned on lab reports, quizzes, and exams. In the comparison group bonus points were awarded to individual students based on individual performance. Course content, tests, quizzes, and other procedures unrelated to the study were identical for the cooperative and comparison groups.

## Treatment Validation

Four procedures were carried out as part of the validation of treatment. Each class was observed on two occasions by at least two observers utilizing the Observational Instrument. Complementing the observations was the administration of the Student Perception of Treatment instrument at the end of the study. Qualitative data relative to student and teacher experiences during the study were also available from eight student interviews and teacher journals.

## Data Analysis

Alpha level was set *a priori* at 0.05. Data analysis was carried out using university computing facilities using SPSSX (Nie, Hull, Jenkins, Steinbrenner & Brent, 1975). The Science Attitude Survey was analyzed as a repeated measure in the consideration of questions relevant to attitude. In the analyses of performance data, SAT-math scores were selected as the covariate for achievement and laboratory practical scores; the course pretest, for the concept test scores.

## Results

The analysis of the results of the Student Perception of Treatment instrument revealed significant ($p < 0.05$) differences between the comparison and the cooperative groups relative to their perception of the nature of the student interactions in the two groups (see Table 1). Results of observations supported this finding though statistical significance was not achieved (see Table 2). Examination of subject interviews and teacher journals, however, indicated that the differences in treatment, while signifcant, were subtle.

No significant main effects of treatment or interactions between treatment and reasoning ability, learning preference, or science comfort level were found ($p > 0.05$). These findings of no significant difference were true across all dependent variables assessed (for example, see Table 3). The subtlety of differences in treatment alone could account for the failure to find signficant differences. Other factors possibly affecting these outcomes are the mismatch between the cooperative treatment and individualized assessment of outcomes; mismatch between learning preferences and mode of assessment of outcomes; and the relationship between length of the study and students' lack of prior experiences with cooperative learning.

While differences were not significant, it should be noted that, while the literature would lead us to expect otherwise, the comparison group outperformed the cooperative

group in 43 of 60 comparisons. These outcomes may have been influenced by a variety of problems inherent to the mismatch between students' enculturation in a competitive educational system and the cooperative methods such as actual resistance to procedures in the cooperative treatment and/or difficulties in adjustment to "new" ways of doing things.

Further examination of results indicated that when class to class comparisons were made, the cooperative classes both outperformed one of the comparison classes in 8 of 12 comparisons. The superiority of the comparison treatment appears to be a function of the singularity of the second comparison class. These results underscore the difficulties encountered when using intact classes and are indicative of the sometimes unique interactions between teaching methods and particular classes and of the well-known fact that not all methods are equally effective for all classes.

It should also be noted that, regardless of treatment, significant improvement in attitude was observed, particularly for students described as "low" on the science comfort index. Given that some degree of interaction was observed in both treatment groups, these results provide some support for the efficacy of groupwork.

Implications for Teaching and Future Research

Based upon the results of this study several recommendations for future research might be suggested. First, the selection of a larger sample of classes from a larger population of classes and the inclusion of a larger

number of teachers with a wider range of backgrounds and experiences would be advisable. Also, the addition of intergroup competition might provide a linkage between the competitive nature of students' prior educational experience and the relatively "new" cooperative experience.

Given the subtle nature of treatment differences, the use of techniques of naturalistic inquiry would be highly recommended for future studies. Information about the nature of interactions between students in the two groups of interest to teachers and teacher educators might be discernable using alternative methods of inquiry.

Qualitative information from student interviews, teacher journals, and informal observer comments were indicative of a "more relaxed," "more serious" atmosphere in the cooperative classes. Given these differences and if, as indicated, cooperative learning has positive impact upon some students without detrimental effects for other students in the class, teachers should perhaps give serious consideration to the implementation of cooperative learning in science classes. Witness the comment of one of the weaker students who happened to be in one of the cooperative classes: "You know, I was really scared about taking this class, but it turned out O.K. But, if it hadn't been for my group, I would never have made it."

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Table 1

Mean Total Score of Items 1 through 12 on the Perception of Treatment Instrument by Treatment

| Treatment | n | mean | SD |
|---|---|---|---|
| Cooperative | 42 | 23.0 | 7.4 |
| Comparison | 42 | 33.3 | 6.4 |
| Total | 84 | 28.3 | 8.7 |

Note: Minimum possible = 12; maximum possible = 60.

Kruskal-Wallis One-way ANOVA: Total Score on Items 1 through 12 on Perception of Treatment Instrument by Treatment

| Treatment | Cases | Mean Rank | Chi-Square* | Sig. |
|---|---|---|---|---|
| Cooperative | 42 | 26.76 | 35.04 | 0.00 |
| Comparison | 42 | 58.24 | | |

*Corrected for ties.

Table 2

Observation Two: Mean Score on Observational Instrument by Section

| Section | No. Observers | mean score | SD |
|---|---|---|---|
| One (Coop) | 2 | 1.4 | 0.0 |
| Two (Comp) | 2 | 4.1 | 0.4 |
| Three (Comp) | 3 | 3.6 | 0.5 |
| Four (Coop) | 3 | 1.4 | 0.2 |

Note: Minimum possible = 1.0; maximum possible = 5.0.

Observation Three: Mean Score on Observational Instrument by Section

| Section | No. Observers | mean score | SD |
|---|---|---|---|
| One (Coop) | 2 | 1.4 | 0.1 |
| Two (Comp) | 2 | 3.9 | 0.3 |
| Three (Comp) | 2 | 3.4 | 0.0 |
| Four (Coop) | 2 | 1.4 | 0.1 |

Note: Minimum possible = 1.0; maximum possible = 5.0.

Table 3

Mean Achievement Scores by Treatment by Reasoning Ability

| | | Achievement | | |
|---|---|---|---|---|
| Treatment | n | obs. mean | SD | Adj. mean |
| Cooperative | 42 | 22.4 | 3.6 | 22.6 |
| nonformal | 18 | 20.3 | 2.7 | 21.5 |
| formal | 24 | 23.9 | 3.5 | 23.5 |
| Comparison | 41 | 24.3 | 3.1 | 23.6 |
| nonformal | 13 | 22.2 | 2.2 | 22.8 |
| formal | 28 | 25.2 | 3.0 | 24.0 |
| Total | 83 | 23.3 | 3.5 | 23.1 |

Note: Maximum possible = 32.5.

Two-way ANCOVA: Achievement by Treatment by Reasoning Ability

| Source | S.S. | D.F. | M.S. | F | Sig. of F |
|---|---|---|---|---|---|
| Regression | 209.49 | 1 | 209.49 | 34.20 | 0.00 |
| Main Effects | | | | | |
| Treatment | 14.07 | 1 | 14.07 | 2.30 | 0.13 |
| Reasoning | 39.86 | 1 | 39.86 | 6.51 | 0.01 |
| Interaction | | | | | |
| Treat x Reasoning | 3.42 | 1 | 3.42 | 0.56 | 0.46 |
| Within | 477.82 | 78 | 6.13 | | |